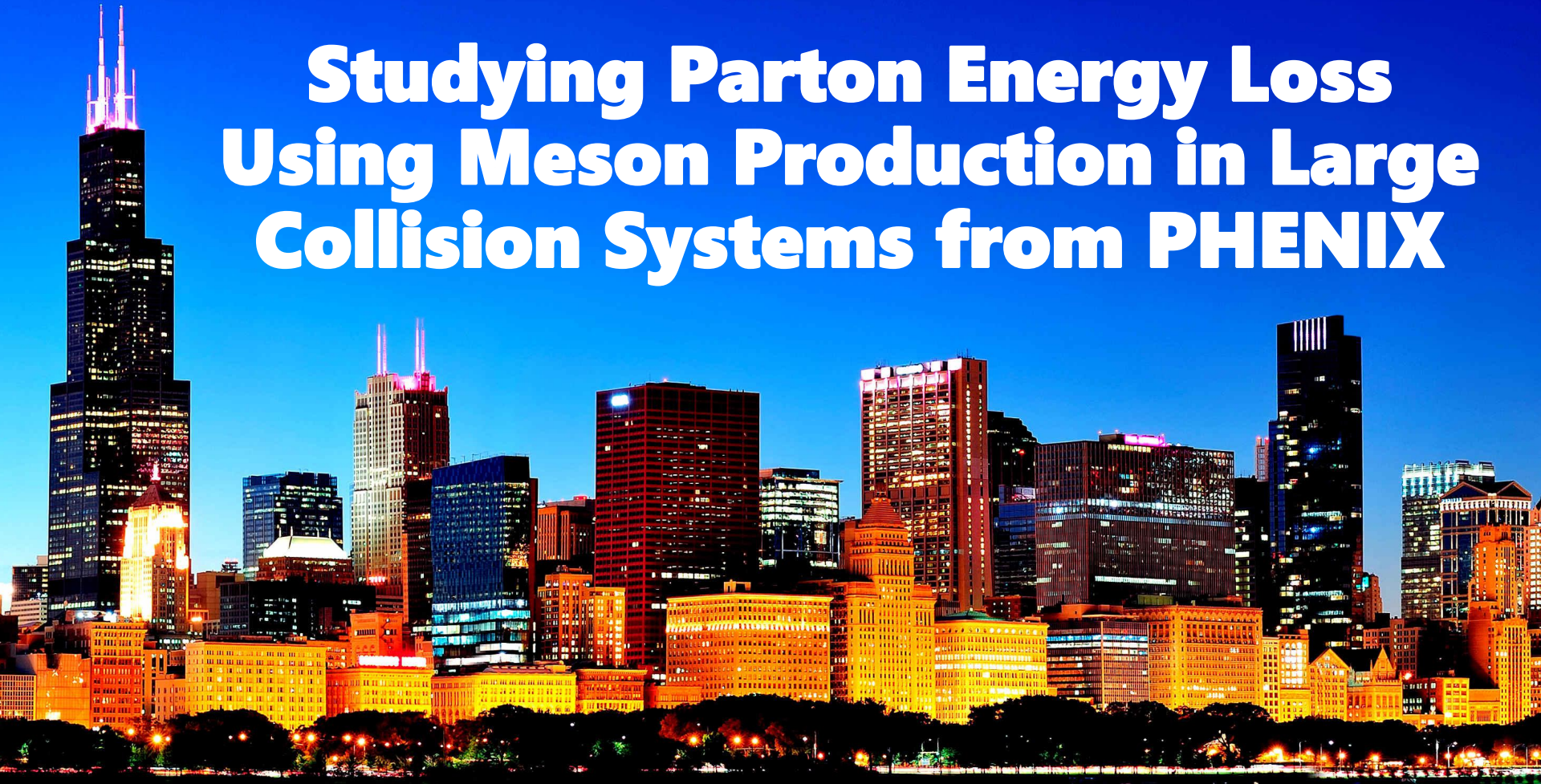


Studying Parton Energy Loss Using Meson Production in Large Collision Systems from PHENIX



Sergei Zharko for the PHENIX Collaboration



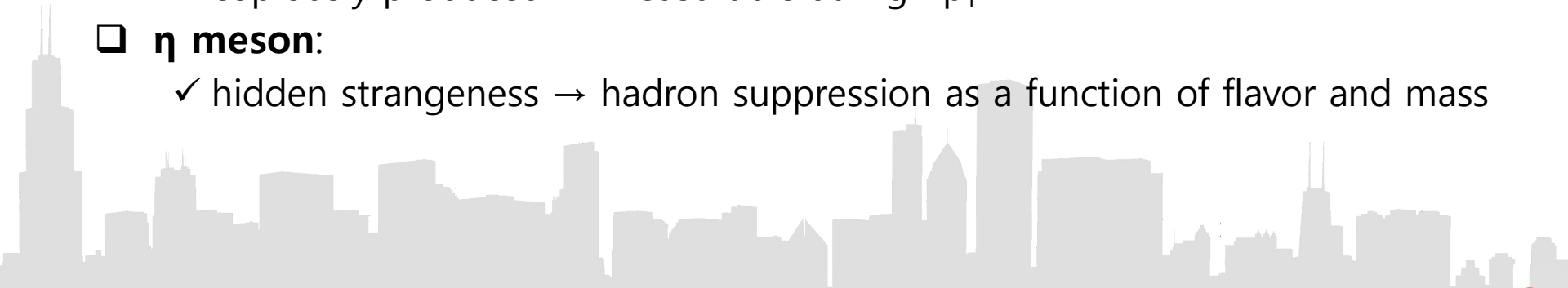
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University

Motivation

- ❑ **Jet-quenching** (energy loss of high-energy partons) - one of the evidences of sQGP formation in central heavy-ion collisions
- ❑ Jet quenching results in suppressed production of leading hadrons from fragmentation of hard partons
- ❑ **Studied by measuring** nuclear modification factors:

$$R_{AA} = \frac{1}{N_{coll}} \cdot \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$

- ❑ **Leading hadrons are used as proxy for jets:**
 - ❑ **π^0 meson:**
 - ✓ copiously produced → measurable at high p_T
 - ❑ **η meson:**
 - ✓ hidden strangeness → hadron suppression as a function of flavor and mass



Motivation

❑ Studying **different** heavy-ion collision systems:

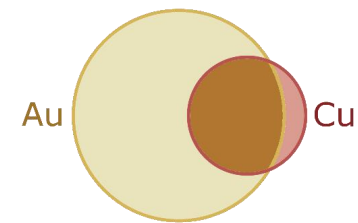
- ✓ dependence of parton energy loss on energy density and nuclei overlap geometry → better discrimination between various theoretical models and understanding of parton energy loss mechanisms

❑ Available A+A collisions at RHIC:

| A+A | Au+Au | Cu+Cu | Cu+Au | U+U |
|-----------------------|--|-----------------|-------|-----|
| $\sqrt{s_{NN}}$, GeV | 7.7, 9.2, 14.6, 19.2, 19.6, 27, 39, 62.4, 130, 200 | 22.4, 62.4, 200 | 200 | 193 |

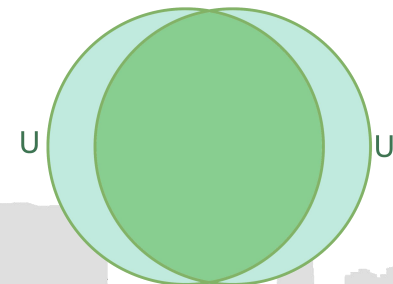
❑ Cu+Au:

- ✓ first asymmetric heavy-ion collision system
- ✓ different overlap geometry compared to symmetric systems



❑ U+U:

- ✓ the largest heavy ion collision system
- ✓ the largest energy density in central collisions



Analysis is progressing, not finished yet

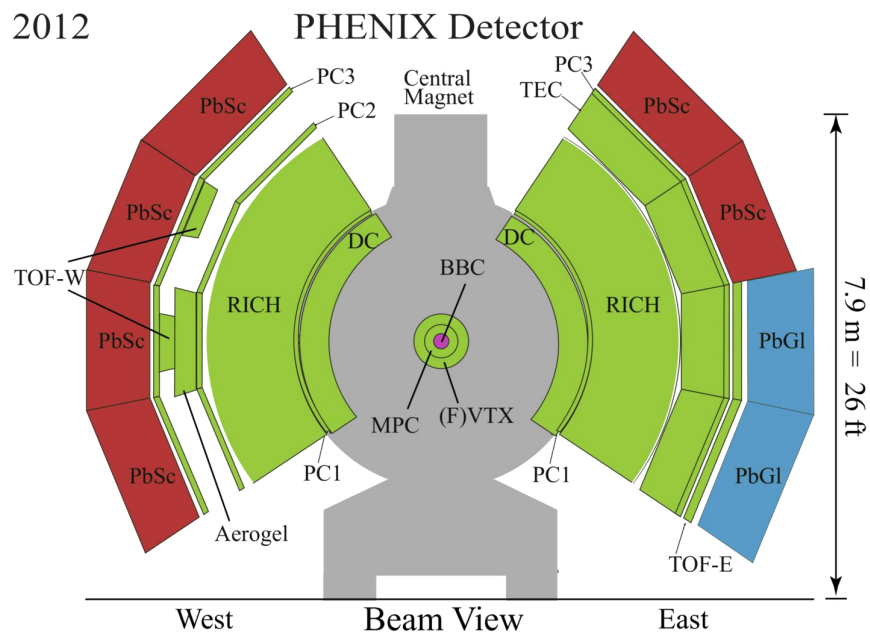
Outline

- ❑ PHENIX detector
- ❑ Neutral pion and eta meson reconstruction
- ❑ p_T spectra and R_{AA} in Cu+Au
- ❑ Comparison with jet results in Cu+Au
- ❑ Comparison with symmetric systems

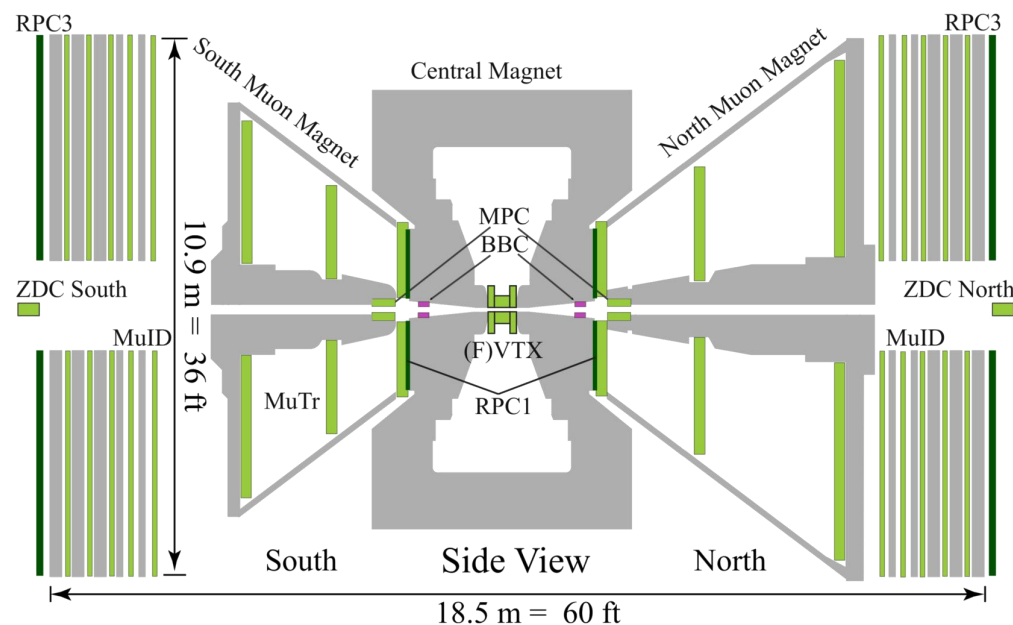


PHENIX Detector

2012



$$|\eta| < 0.35, \Delta\varphi - 2 \times 90^\circ$$



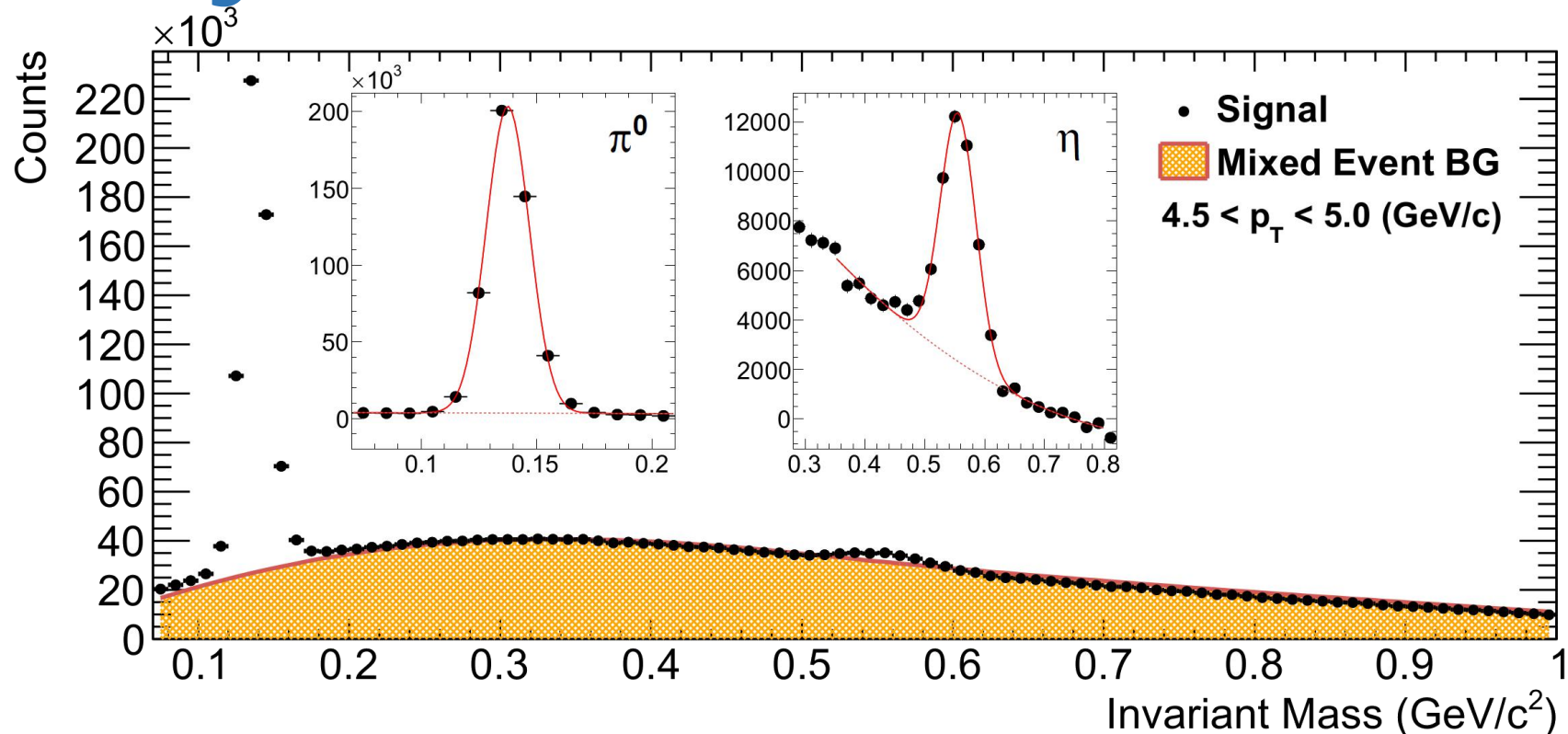
$$1.2 < |\eta| < 2.2, \Delta\varphi - 360^\circ$$

❑ **Beam-Beam Counters:** vertex and centrality classifications

❑ **Electromagnetic Calorimeter (PbSc/PbGl):**

- ✓ reconstruction of γ -clusters from $\pi^0 \rightarrow \gamma\gamma$ and $\eta \rightarrow \gamma\gamma$ decays
- ✓ energy resolution: **PbSc** - $\delta E/E = 2.1\% \oplus 8.1\%/\sqrt{E}$, **PbGl** - $\delta E/E = 0.8\% \oplus 5.9\%/\sqrt{E}$
- ✓ online trigger for events with high- p_T clusters \rightarrow larger sampled statistics

Analysis info



- ❑ π^0 and η are reconstructed by combining pairs of γ clusters in the EMCal
- ❑ Combinatorial BG is estimated using mixed-event technique and subtracted
- ❑ π^0 peak is better pronounced because of:
 - ✓ higher production rate and reconstruction efficiency
 - ✓ larger branching: $\text{BR}(\pi^0 \rightarrow \gamma\gamma) = 0.998$, $\text{BR}(\eta \rightarrow \gamma\gamma) = 0.39$
 - ✓ smaller width: $\sigma(\pi^0) \sim 10 \text{ MeV}/c^2$, $\sigma(\eta) \sim 30 \text{ MeV}/c^2$

Analysis info

❑ **Reconstruction efficiency** → correction for detector effects and acceptance

❑ **π^0 meson:**

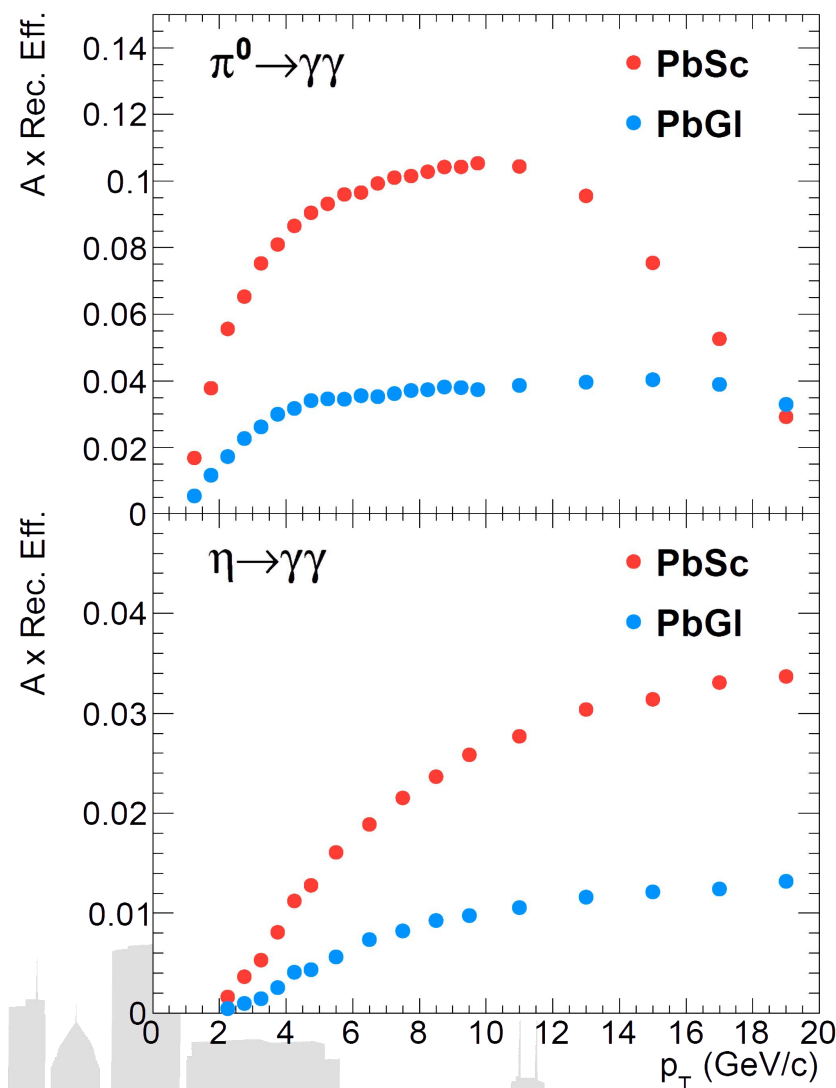
- ✓ reliably identified with good S/B ratio → relatively small uncertainties
- ✓ cluster merging in PbSc at high p_T

❑ **η meson:**

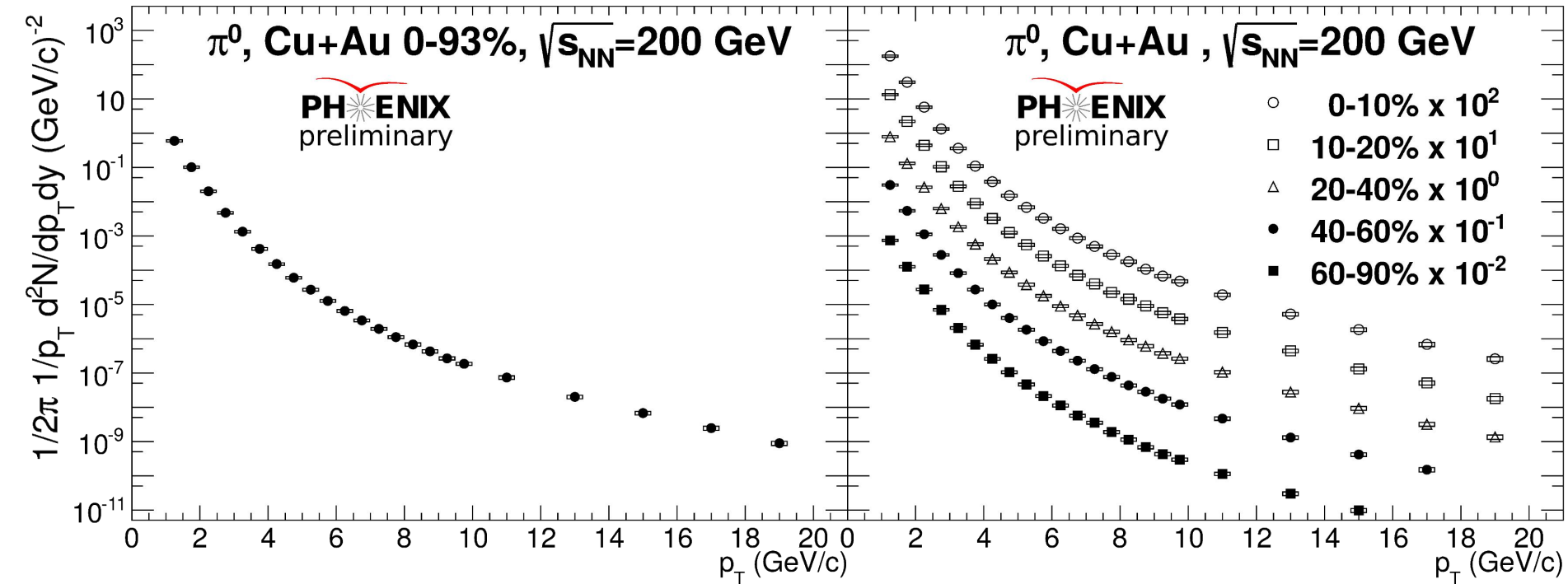
- ✓ does not suffer from cluster merging effect → well controlled systematic uncertainty at high p_T

❑ Measurements are carried out separately in PbSc and PbGl → comparison of results is an important cross check

❑ Final results are averaging of PbSc and PbGl spectra with weights defined by uncorrelated stat. and syst. uncertainties



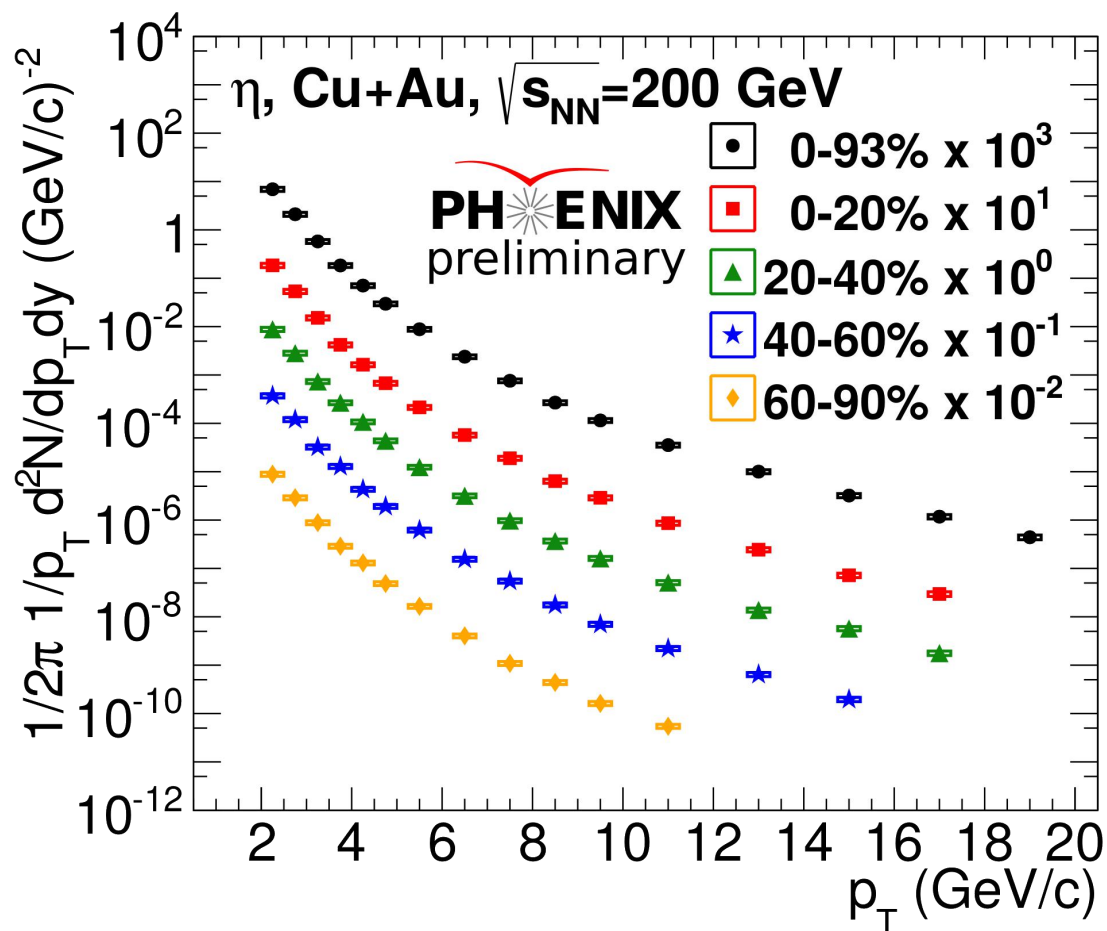
π^0 spectra in Cu+Au



Measured in a wide p_T range: up to 20 GeV/c in central collisions and semi-central collisions, and up to 16 GeV/c in peripheral

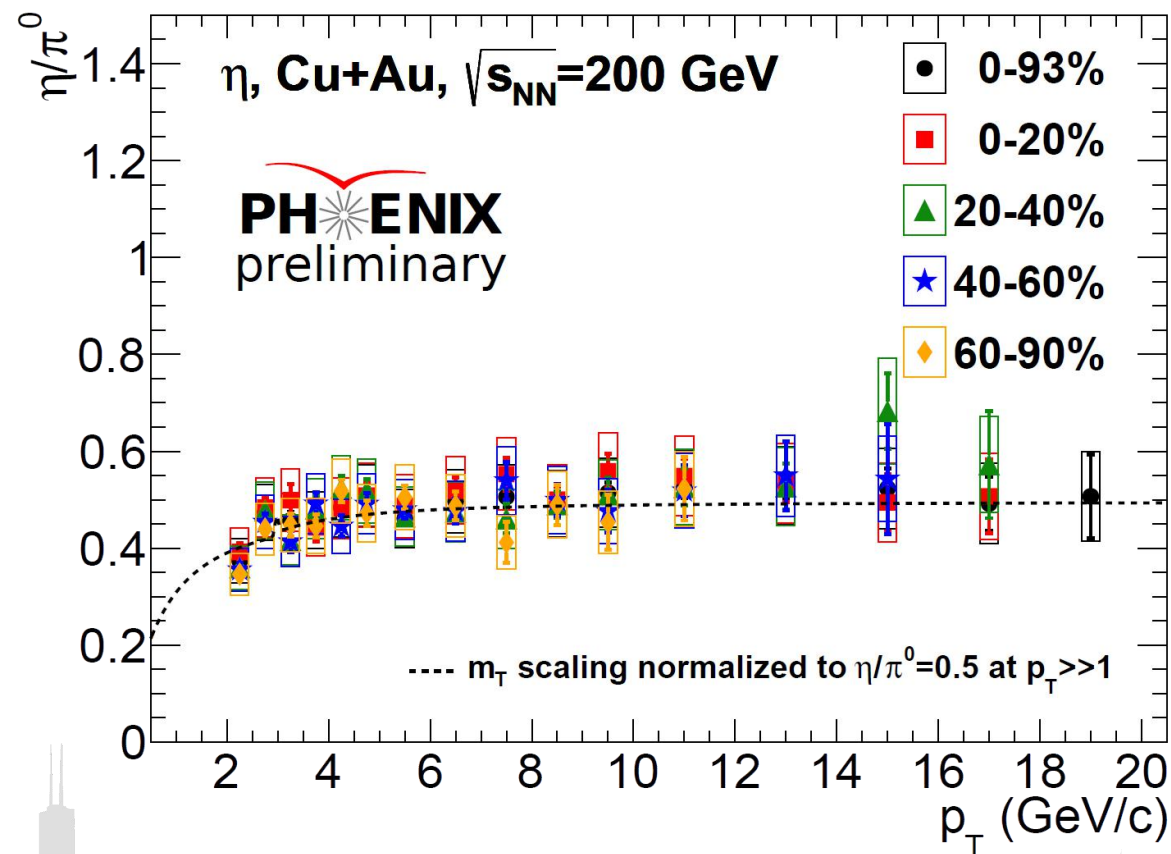


η spectra in Cu+Au



Measured up to 20 GeV/c in MinBias, 18 GeV/c in central and semi-central collisions, and up to 12 GeV/c in peripheral

η/π^0 ratios in Cu+Au



η/π^0 is consistent with the m_T -scaling curve, normalized to 0.5 at high p_T

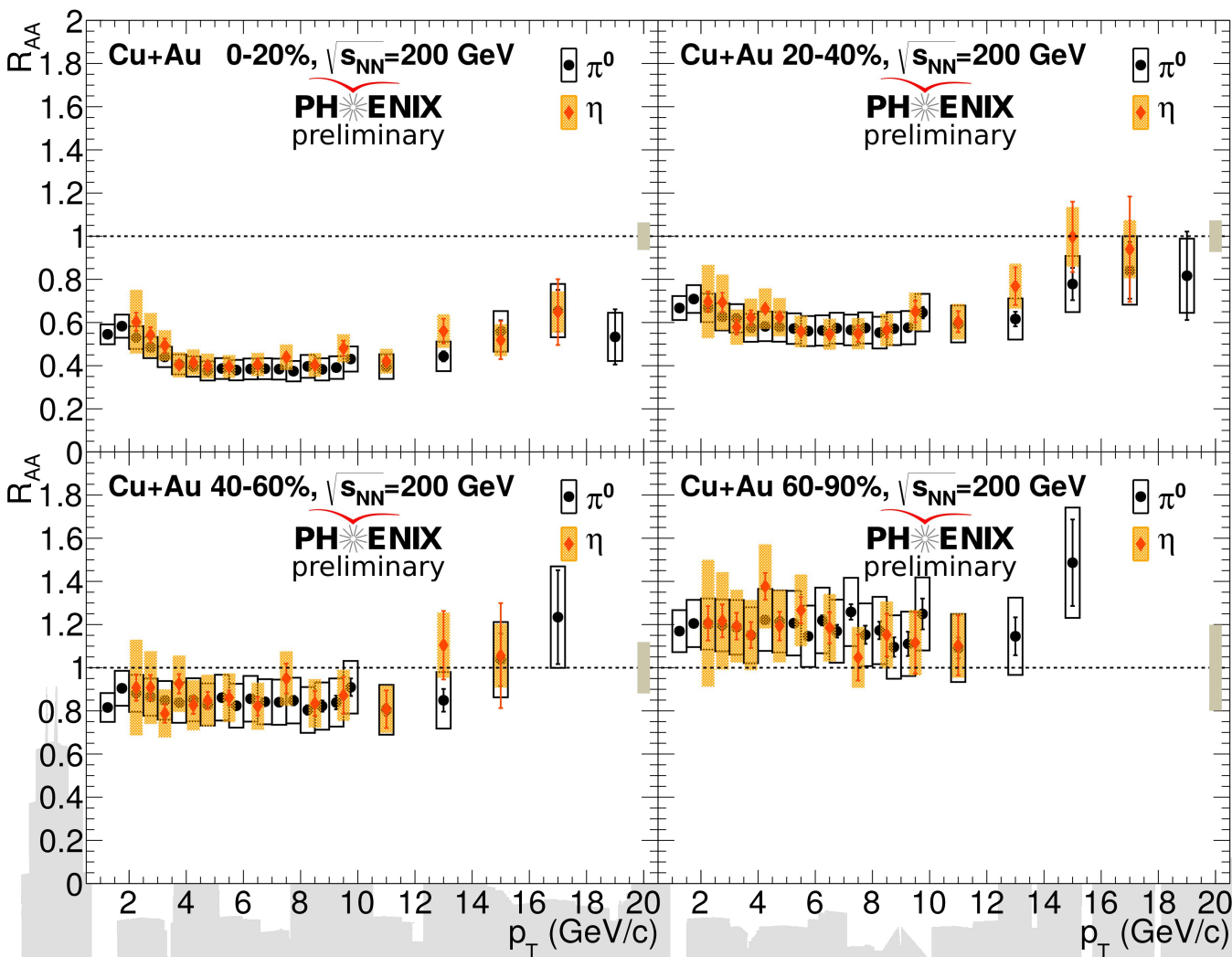
No obvious radial flow effect at intermediate p_T

η/π^0 is consistent with that measured in pp, pA and A+A collisions at different energies



PHENIX [Phys.Rev. C75, 024909 (2007)]
CCRS [Phys. Lett. B 55, 232 (1975)]

π^0 and η R_{AA} in Cu+Au: centrality dependence

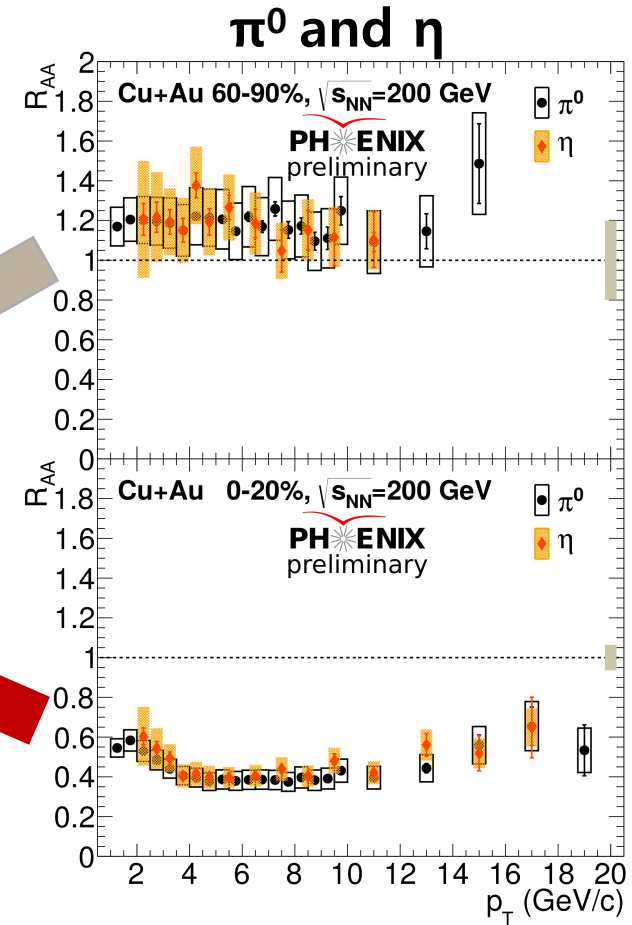
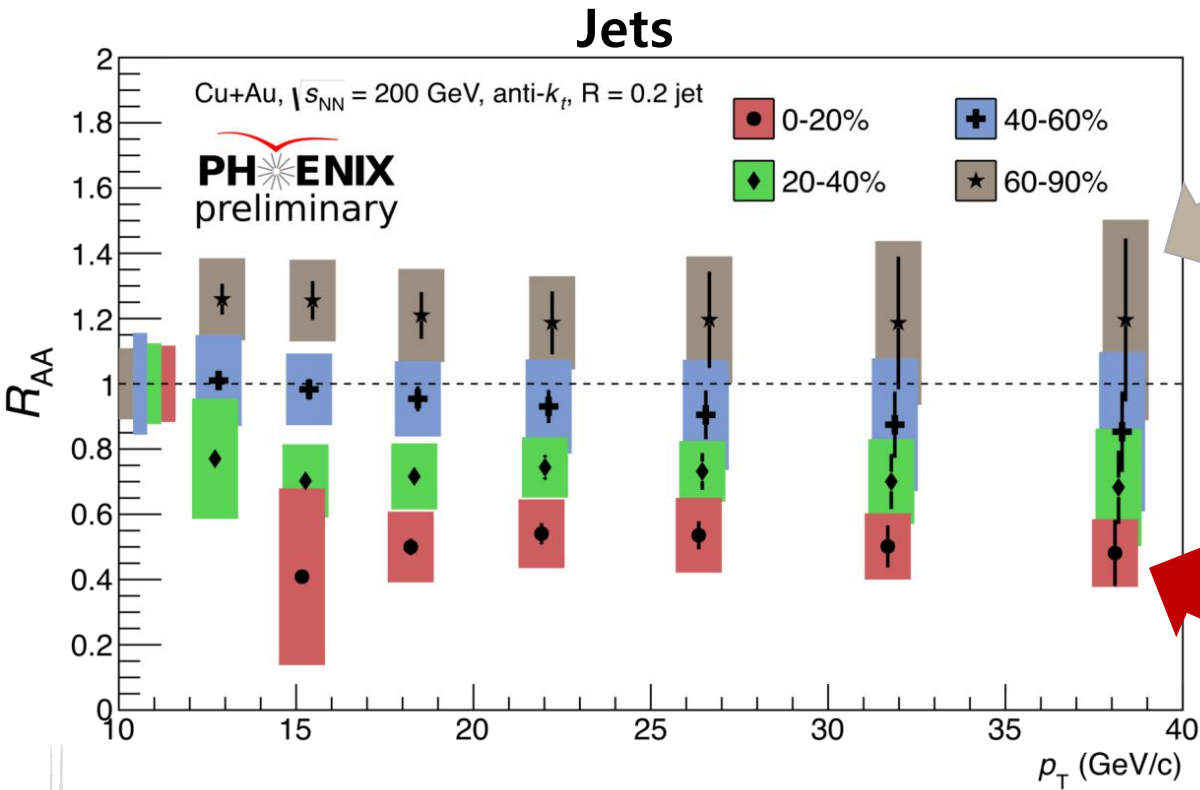


□ R_{AA} for π^0 and η show good agreement, similar to that in Au+Au

□ In **central** and **semi-central** Cu+Au collisions π^0 and η production is suppressed

□ In **peripheral** Cu+Au collisions observe a hint of enhancement

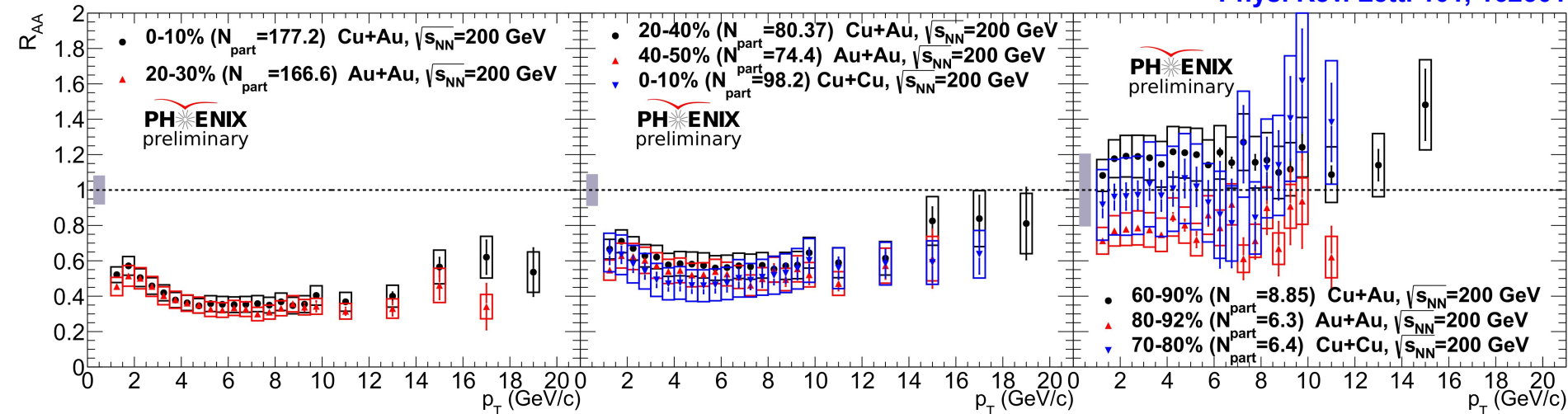
Comparison with jets R_{AA} in Cu+Au



□ π^0 , η and jets show similar centrality dependence of R_{AA}

π^0 R_{AA} in Cu+Au, Au+Au and Cu+Cu

Phys. Rev. Lett. 101, 232301
Phys. Rev. Lett. 101, 162301



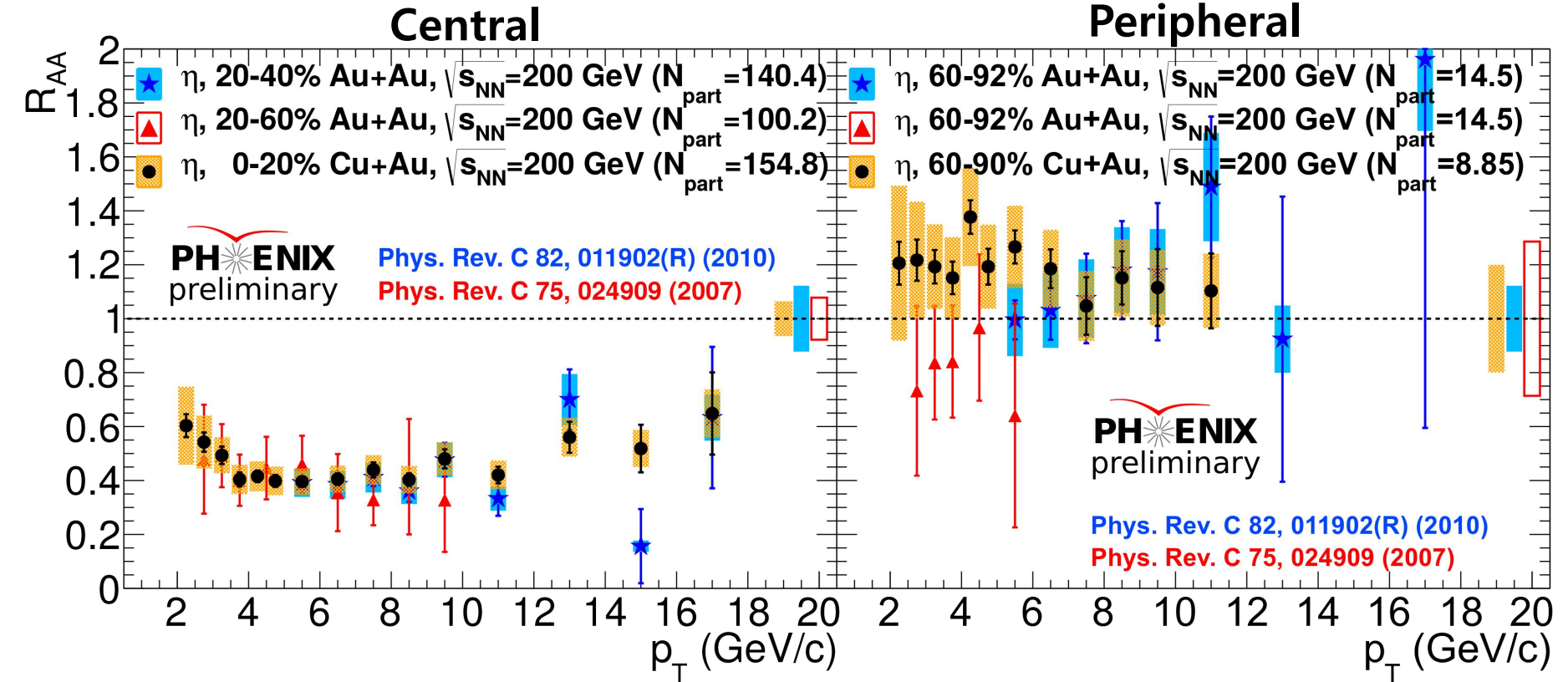
❑ In **central** and **semi-central** **Cu+Au** collisions π^0 yields are suppressed as in **Cu+Cu** and **Au+Au** at similar N_{part} :

✓ π^0 production depends on the size of the nuclear overlap, but not on it's shape

❑ In **peripheral** **Cu+Au** collisions π^0 yields show a hint on enhancement while in **Au+Au** – suppression, **Cu+Cu** is in between

| $\langle T_{ab} \rangle$ | central | semi-central | peripheral |
|--------------------------|---------------------------------|---------------------------------|-----------------------------------|
| Au+Au | 8.9 ± 0.7 | 2.9 ± 0.3 | 0.12 ± 0.03 |
| Cu+Cu | - | 4.4 ± 0.4 | 0.12 ± 0.02 |
| Cu+Au | 8.9 ± 0.6 | 3.1 ± 0.2 | 0.18 ± 0.04 |

η R_{AA} in Cu+Au and Au+Au



At high p_T production of η in **Cu+Au** is suppressed in the same way as in **Au+Au** at similar N_{part}



Summary

- ❑ PHENIX has measured p_T spectra and nuclear modification factors for π^0 and η in Cu+Au collisions at 200 GeV
- ❑ R_{AA} factors for π^0 and η are consistent within uncertainties at all momenta and centralities
- ❑ In central and semi-central Cu+Au collisions production of π^0 and η is suppressed in the same way as in Au+Au and Cu+Cu at similar N_{part} :
 - ✓ the suppression level is dependent on overlap size, not on its geometry
 - ✓ a hint of enhancement is observed in peripheral Cu+Au collisions

